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A NATIONAL PROGRAM OF RESEARCH
FOR FORESTRY

Property of
U. S. Forest Service
Rocky Mountain Forest and Range
Experiment Station

Prepared by a Forestry Task Force
for the Agricultural Research
Planning Committee of the U. S.
Department of Agriculture and
the State Universities and Land
Grant Colleges

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Foreword

This report presents a national program of research for forestry within the framework of A National Program of Research for Agriculture. Research to be undertaken through USDA and the educational institutions making up the Association of State College and University Forestry Research Organizations (ASCUFRO) is included. The Agricultural Research Planning Committee (ARPC) initiated development of the program through their selection of forestry as one of the subject matter areas in agriculture which should be intensively reviewed as a necessary step toward implementation of long range plans.

The program was submitted to ARPC on May 23, 1967. At that time ARPC accepted the Forestry Task Force Report and approved of its release with minor changes. A more concise and illustrated draft of the report is to be published later.

A National Program of Research for Agriculture aggregates agricultural and forestry research into broad problem areas and recommends for each, the level of program to be attained in 1972, and 1977, 5 and 10 years after the completion of the study. A further analysis of each problem area is being undertaken as a means of developing more specific programs. A forestry task force was set up to develop such a comprehensive and coordinated research program for forestry. Other Task Forces are now involved in similar analyses for other subject matter areas, some of which involve problem areas related to forestry. When the reports of these other task forces are complete, it will be possible then to get a view of the full scope of each subject matter area and to correlate research proposals which deal with areas of common interest. For example, problem area 107, Technology of Watershed Conservation, includes research proposed for problems on forest lands as well as on agricultural lands. The Forestry Task Force is presenting its recommendation for the research proposed for forest lands.

The research program which follows covers the entire field of forestry as defined in the Hatch Act granting Federal aid to the State Agricultural Experiment Stations (SAES), the McSweeney-McNary Act specifically authorizing a broad program of forestry research in USDA, and the McIntire-Stennis Act (MS) extending Federal assistance to the universities for forestry research. It includes the research support required for

effective management of Federal, State, other public, and private lands, and for efficient production, processing, and marketing of the goods and services they furnish.

As noted above, this forestry program constitutes one phase of the research outlined in A National Program of Research for Agriculture. The agricultural program grew out of the need to coordinate a large number of diverse research efforts into a single plan with proper emphasis and balance. It differs from earlier plans in that research of the States is included in addition to that done by USDA itself.

This research program for forestry includes the research both of the State Agricultural Experiment Stations and of certain universities which participate in the McIntire-Stennis program but are not associated with an Agricultural Experiment Station. Approximately eight percent of the forestry research is at these non-land grant public institutions.

This forestry research program supersedes A National Forestry Research Program developed by the Forest Service, USDA, which was published in 1964. The program which follows was prepared by representatives of USDA and the State research organizations. USDA members of this Forestry Research Task Force were appointed by Assistant Secretary George Mehren. Members representing the States were selected by the President of the Association of State College and University Forestry Research Organizations, Richard Preston, who was also a member of ARPC. The membership of the Forestry Task Force was:

M. B. Dickerman, Cochairman
Forest Service
USDA

Frank H. Kaufert, Cochairman
University of Minnesota
School of Forestry

James S. Bethel
University of Washington
College of Forestry

Hugo O. Graumann
Agricultural Research Service
USDA

Philip N. Joranson
Cooperative State Research Service
USDA

Henry J. Vaux
University of California
School of Forestry

The Task Force gratefully recognizes the substantial contribution of R. D. McCulley of the Forest Service, USDA who did much of the staff work.

FORESTRY HAS AN IMPORTANT ROLE IN THE NATIONAL ECONOMY

After more than three centuries of settlement and development, forests still occupy one-third of our lands and supply us with more than ten billion cubic feet of wood each year. But, forestry activities add more than wood to the National Economy: ranges for grazing; habitats for wildlife and fish; thousands of areas and facilities for recreation; watersheds on millions of acres; and the protection of wilderness as well as some plants and animals that are near extinction. Even in the Great Plains and in the crowded cities, woodlands, shelterbelts and trees add to property, industrial, and human values. Forestry activities, therefore, will continue to have a widespread environmental influence on the Nation's culture and on the well-being of its citizens.

Nearly three-fourths of the forest area is classed as commercially suitable and available for the growing of timber. Nearly 245 million acres of forest and related range lands are grazed by domestic livestock and a much larger acreage by big game. The headwaters of our major river systems are in forested areas and these forests play a vital role in the timing of runoff, control of the rate of infiltration of moisture into the soil, and protection of the surface from erosion. The same lands supply a large measure of the national demand for outdoor recreation. Through multiple use management these overlapping and sometimes conflicting uses are developed together in combinations that best supply the needs of the nation as a whole.

Timber harvested from U. S. Forests totaled 10.3 billion cubic feet in 1962. About half of this was in the form of sawlogs and another 25 percent as pulpwood. The rest was in veneer logs, other miscellaneous industrial wood, and fuel wood. This production was insufficient to meet the Nation's needs for all types of products desired as evidenced by the 1.5 billion cubic feet imported from foreign sources. The domestic production came from all sections of the country. It was made up of logs from approximately 100 commercially valuable species of native trees growing in a wide variety of mixtures and combinations. The variations in climate, soils, topography, and composition of the forest growth in the several forest regions required locally adapted methods of culture and harvest.

Range grazing for domestic livestock, primarily in the West, takes place on low elevation desert lands and high elevations above timber line as well as on range intermingled with forest. It supports about one-half of our beef cattle and more than three-fourths of our sheep for at least six months of each year. About one-third of the range is in the forest or closely associated with it. Twenty-three percent of the grazing land is publicly owned and used under permit.

Watershed values are involved in the management of forest land for all other uses and constant vigilance is required to make sure that standards required for watershed protection are observed. Water yield from much forest land and related range has deteriorated in quality and probably in timing as a result of heavy use. There is strong demand for increase in water yield through manipulation of vegetation. As management becomes more intensive, improvement in practices that protect the watershed must compensate for sharply increasing pressure for timber, recreation, and other uses.

Game birds, fish, and other animals have long been recognized as products of the forest. Their numbers have fluctuated considerably as a result of changes in habitat due to timber harvest and fire protection. But until recent years, little was done directly for game management purposes. Emphasis was on estimating numbers of fish, birds, and other animals and on controlling harvest through game seasons and other restrictions. As a result habitats have changed or deteriorated and in some instances this has resulted in reduced numbers or in over-population of animals. Thus interest in managing animal habitats has increased markedly. Also there is much greater recognition at present than in the past of the importance of wildlife from the aesthetic standpoint. We are becoming more fully aware of the contribution that all birds and animals make to a satisfactory forest setting. Also, there is concern about protecting endangered species such as the California Condor, Kirtland Warbler, and the Ivory Billed Woodpecker.

Forest lands have provided recreation from the time of early settlement. In the beginning there was little impact on forest management requirements. There were no specialized facilities and access by trail was justified for other purposes. Then came the development of campgrounds, particularly in park areas, and related improvements, that made forest recreation a more enjoyable experience for larger numbers of people. Some 14 million acres of wilderness in the National Forests have added to the potential. Recreational use now is a major concern in the management of both public and private forests. And on some private lands recreation yields income to investors from commercial development.

All these products and services: timber, range, water, wildlife and recreation, make up the bounty of forest land. Forestry research supplies the information required for their production, for maintenance of productivity of the land, and for resource policies that provide a sound framework for management. Study of the growth of trees, whatever the surrounding environment, is a fundamental part of the research. Forestry research therefore is concerned with the preservation, production and use of wood, water, range, recreation, wildlife habitat, and the ingredient that binds them together - trees.

The program which follows includes the research performed or funded by the U. S. Department of Agriculture and State universities. Private educational institutions and industries also perform forestry research or biological research fundamental to work on many forestry problems. The development of research programs and to some extent the funding are interrelated. Coordination of efforts to avoid duplication and assure efficient use of research resources is essential. Providing overall guidance is this jointly planned State-Federal program of research. In addition, the Department of Agriculture has a project information system under which all proposals by research agencies of the Department are reviewed and coordinated. Technical advisory committees composed of university, industry, and Federal scientists meet regularly to discuss research plans and projects underway. Formally constituted regional research committees plan and carry out joint research on problems of interest to several States. Special panels of industry representatives are organized periodically to review and coordinate research in special problem fields such as seasoning of wood, or glues and gluing. Committees are frequently formed to coordinate research on special problems such as chemical pesticide research or brush control studies. Advisory committees to USDA, which include representatives from the State and industry, annually review the national program of forestry research conducted by the Department and State scientists.

DEVELOPMENT OF FORESTRY AND SUPPORTING RESEARCH IN THE UNITED STATES

A major natural resource in early America was timber. It was used for construction tools, plows, wagons, furniture and was a part of almost everything made by the early settlers. The pressure for open agricultural land resulted in forests being cleared from the best soils. By 1873 forest depletion caused sufficient concern about the future supplies of timber and the related effects of water quality and supply that the American Association for the Advancement of Science memorialized Congress and the State legislatures on the importance of cultivating timber as a crop and preserving the forests.

The first stirrings of forest conservation brought about the establishment of a Division of Forestry in USDA which had as its function broad investigation of the Nation's forestry resources. Forestry resources were involved in grants of public domain to encourage settlement, development of transportation, educational improvement, and the like, but large acreages remained in Federal ownership. When administration of a large segment of these forest reserves was turned over to USDA in 1905, forestry research investigations received added impetus.

Research relating to forestry provided some of the background for the conservation movement through early work on the identification and classification of forest plants. One of the pioneering works was North American Sylva published in 1849. Then when the USDA Commissioner of Agriculture was directed to appoint a special agent to study the forests in 1876, research was one of his major responsibilities. The research effort in USDA gradually increased through selected investigations carried on as part of the responsibilities associated with land management. A Regional Forest Experiment Station was established in 1908. The Forest Products Laboratory came into being in 1910 through cooperation with the University of Wisconsin. A major advance came in 1915 with the establishment of a Branch of Research in the U. S. Forest Service, thus making research an activity co-equal with management of the National Forests. The breadth of the Federal forestry research program was spelled out in the McSweeney-McNary Act of 1928 which provided the charter for development of forestry research as it is known today in the U. S. Department of Agriculture.

University research had its beginnings at about the same time. The Arnold Arboretum was established in 1873 and during the ensuing years Professors Sargent at Harvard and Brewer at Yale published important descriptive material. The first professional forestry school was established at Cornell University in 1898. Although research was soon undertaken in these schools, it was limited for many years by the smallness of the group of scientists and their large teaching responsibilities. Even so, the contributions of the forestry professors to the knowledge of forestry were magnified considerably by the common arrangement for them to conduct research for the U. S. Forest Service during vacation and leave periods.

Expansion of research at the universities has come about largely since 1945. Appropriation of State funds for work at the universities has been stimulated by public recognition that the forest resources of the Nation need greater research attention than they have been receiving. Cooperative programs between the U. S. Forest Service and the universities have been developed and there has been an upward trend in Federal funding. Industry supported research at the universities has increased also.

Strong stimulus to university research in forestry resulted from the enactment of the McIntire-Stennis Cooperative Forestry Research Act in 1962. Paralleling the Hatch Act for agriculture, under which some university research in forestry is also supported, this program provides the means, by formula allotment, for funding a broadly defined program of forestry research through grants matched by the States. At present, 60 State universities participate. The program is administered by the USDA Cooperative State Research Service.

The forest industries in recent years have built up substantial research capability, particularly in the pulp and paper industry. To a considerable extent such industrial research emphasizes the design, development, and marketing of specific forest products, with less emphasis on basic studies, resource management problems, and uses of the forest other than wood production. Because of the vital role of wood products in the American economy, this forest industries research effort provides a large and essential complement to the Federal/State research program for forestry.

RESEARCH. THE KEY TO THE IMPROVEMENT AND USE OF FOREST RESOURCES

The degree to which future production from forest and related range lands will effectively supply the needs of the American people will be greatly influenced by the information developed through research.

Basic data on the distribution of forest acreage and timber through the Nation by States and by units within States are being provided on a periodic schedule by the Forest Survey. These data supply an essential ingredient to both public and private planning for resource development.

Research on new equipment and methods of fire suppression, and on techniques of prescribed burning to reduce dangerous accumulations of fuel are responsible in part for the increased effectiveness of fire protection year by year. Recent developments include new methods for mapping fires from the air with infrared sensors and the reduction of devastating lightning storms through cloud seeding.

Basic knowledge of forest trees and associated vegetation is being added to regularly through research and is published periodically in such compilations as the Loblolly Pine, Longleaf Pine, Balsam Fir, Aspens, Woody Plant Seed Manual, and the Silvics of Forest Trees of the United States. Regional advances in applied fields such as seeding and planting and associated nursery practice are available in summary form for species groups such as southern pines and for geographic area such as the Lake States.

The outlook for the future in timber culture is indicated by much recent progress on selection of genetically superior individuals from the major species groups in the country and associated development of hybrids, several of which are now in production for outplanting in forest land administration and development.

Losses from insect attack have been reduced with greater safety through improved technology of chemical pesticide application. Biological controls such as risk reduction cutting in ponderosa pine, introduction of predators, and the use of bacteria and virus spray formulations have been provided through research to reduce the need for chemical pesticides.

Diseases of forests have been curbed through such methods as the eradication of alternate hosts to protect trees from rusts and through specifications for pruning in high value locations to minimize rust damage. Dwarf mistletoe infection is controlled through systems of sanitation cutting based on knowledge of seed dissemination, which halt transmission of the disease to uninfected trees.

Utilization of wood products from the forests has been aided and new markets developed through research which produced the semi-chemical and cold soda pulping processes, which use hardwoods that otherwise would have little or no market. Industrial development has been fostered by new products and improvement of old ones. The southern pine plywood industry is an example. And undergirding all use of wood is the basic knowledge of its structure, chemical components, and physical properties, that is essential to new advancement.

Watershed values have been enhanced through techniques for water yield improvement as the result of vegetation manipulation and high altitude snow management.

Range has been protected and rehabilitated through new techniques for conversion of brush to grass, through seeding of improved species, and through introduction of livestock control in new systems of management.

Economics research has led to improved systems of forest taxation and has fostered the application of more efficient management planning. Several studies of long term supply and demand for forest products have provided major guide posts for the Nation's developing forest policy, and research has provided the beginning of a solid statistical base for recreation management and techniques for protection of vegetation vital to recreational use.

The future poses new challenges and opportunities for forestry. By the year 2000 the population of the United States, approximately 325 million people, is estimated to require at least twice as much timber as is now being produced. Some of those needs are in areas of current short supply.

Forest fires, insects, diseases, and other destructive agents continue to take a heavy toll of forest growth. They constitute a serious drain on timber resources and growth potential. Newly discovered destructive diseases and insect pests are a serious threat to expanding tree planting activities and intensified forest management programs.

Recreational use of forests is climbing rapidly. The current estimate of one billion visits annually to forest lands for recreation is expected conservatively to increase three fold by the year 2000.

The country's 940 million acres of grazed range are more than one-third forested or intermingled with forests. Much of this land is vital watershed area. A continuation of the trend toward greater consumption of beef both at home and abroad will require use of these lands for grazing but at the same time watershed values must be protected.

Forests and related range lands provide the main habitat for 10 million big game animals and countless other forms of wildlife. Thousands of miles of forest streams provide habitat for fish. Today a hunter or fisherman lives in every third home and the numbers are increasing and adding to the demands for increased fish and wildlife resources.

The needs for water are estimated to increase from the present use of 320 billion gallons per day to 600 billion gallons by the year 1980. Since more than half of the Nation's streamflow originates on forest lands, the future protection and management of these watersheds to maintain and increase good quality water supply is an absolute necessity.

The expanding needs of the Nation's future economy can best be met with a rich and abundant natural resources base. Wood, the most versatile of raw materials, occupies a key place in providing the needed structural material, fiber, extractives, and other chemicals. But improved and more efficient utilization of forest products must be achieved in the face of general lowering of quality and size of timber trees.

Needs for all forest and range resources are mounting rapidly. These pressures against the forest resource base give sharp emphasis to conflicts in use that are occurring now and will be more likely to increase in a greater range of situations in the future. They stress the need for harmonious management of forest and range lands to get maximum benefits under the principles of multiple use.

The outlook for the future in forestry is strongly influenced by the growing realization of a large segment of the American people that the aesthetic contribution of trees and all that this implies has great significance. This does not discount the fact that forests produce a basic raw material that is essential to health of the economy or that

the need for wood products is expected to expand substantially in the years ahead. What it does mean is that in addition to the value of forests for the raw materials basic to industrial production, there is an increasing need for trees in both rural and urban settings where their culture is oftentimes difficult. It means that trees in the forests have growing value for the part they play in making recreational experience more satisfying. It means that wildlife demands must receive more attention in the future in the selection of management alternatives for forested areas. And finally it is apparent that the increasingly complex interrelationships now being encountered between timber and other products and uses of the forest which determine the pattern of multiple use management, require a fund of basic knowledge far more extensive than was necessary in the past.

Adequate supply and development of the five basic forest resources can be achieved (1) by greatly intensified forest development and management, and (2) by an increase in utilization proficiency. Greater skill must be brought to bear on intensive measures for producing forests and protecting them from fires, insects, diseases, and animal pests. Special emphasis must be given to increasing the supply of water, forest recreation, and fish and wildlife. Utilization of wood can be improved by greater efficiency in processing, development of better products that will give superior service, and the discovery of many new uses that will capture the natural advantages of wood's versatility as a raw material.

In foreign trade the United States is a net importer of forest products. This is likely to continue, with the volume increasing at approximately the same rate as the expected rise in total domestic consumption. Some relief from particular problems of supply can thus be anticipated through imports such as the current importation of substantial quantities of hardwood veneer stock. But there is no prospect of filling broad scale needs from foreign sources.

The pattern of rapidly increasing use of forest resources and the need for greatly intensified management brings sharply into focus the need for broad supporting research programs. The Nation cannot tolerate inefficient and high cost forest management practices fostered by lack of knowledge. It cannot much longer accept annual destruction of timber and growth losses that almost equal yearly sawtimber utilization because more effective measures of protection have not yet been developed.

It cannot stand by and see forest and range watersheds deteriorate further because of the absence of practical corrective techniques or effective preventive measures to stabilize soil and prevent erosion and sedimentation. In areas of critical water supply, it cannot forego the increased water yields from forests that could come from proper management of forest vegetation. It cannot continue to accept only partial utilization of all the forest resources because of lack of knowledge and of the technology that would stimulate use. It cannot continue to see conflicts in resource use become more and more complex when systematic study would help materially to relieve such problems. In short, the Nation's future requirements of forest resources can be met only if production, protection, and utilization programs are developed and accelerated with the full support of complete, farsighted, and imaginative research programs.

THE RESEARCH PROGRAM FOR FORESTRY

The program presented here is geared to supply the high priority forestry research needs projected in A National Program of Research for Agriculture. It will serve to guide the development of research by USDA and the State universities participating in the McIntire-Stennis Cooperative Forestry Research Program and in the Hatch Program.

Every problem area involves contributions to the agricultural research goals that are selected in A National Program of Research for Forestry. Within each goal a number of problem areas are identified. Each of these problem areas are presented and discussed separately. The number of scientist man years to complete the research are given. The research questions for each problem area are outlined.

For each problem area in this report the Forestry Task Force gives the number of scientist man years (SMY's) which it estimates are needed to make reasonable progress on a problem by 1972 and 1977. The number of scientist man years inventoried for 1965 and identified as forestry research were taken as the base for the study. To this was added the number of SMY's reported by the participating forestry schools at non-land-grant State institutions. From this adjusted base, projections were made of SMY's needed by 1972 and 1977.

The National Program of Research for Agriculture, 1966, lists SMY's for each of 91 problem areas. Some of these problem areas consist entirely of forestry while others have some forestry and some agriculture. For those problem areas which consist in part of forestry, the Task

Force estimated that number of SMY's which relate to forestry and then used this estimate for 1965 and projected it to 1972 and 1977. For example, Problem Area 107, Technology of Watershed Conservation, showed in the 1965 inventory 125 SMY's in the USDA and in the State supported institutions. The Forestry Task Force identified 73 of these SMY's as related to Forestry. The adjusted base for the projection in Problem Area 107 for the forestry component was determined by adding these 73 SMY's to 1 SMY for the participating forestry schools at non-land-grant State institutions. The total, 74, is the inventory figure shown in Table 1 for Problem Area 107. The other adjusted inventory figures were derived in a similar way.

The levels of scientist man years (SMY) proposed for 1972 and 1977 are 2131 and 2870 respectively. This includes 156 SMY's and 225 SMY's respectively, in the participating forestry schools at non-land-grant State institutions. The percentage increase for the total program from the 1965 inventory base is 48 percent to 1972 and 100 percent to 1977.

This program will require added resources of trained manpower, facilities and equipment for both USDA and the States. From the 1965 inventory to the 1977 projected program, about 1437 additional scientists will be needed in the USDA and School-State programs.

Laboratory and office space totaling 1.8 million square feet will need to be constructed to house the program by 1977, and .2 million square feet of existing facilities will need to be replaced. Supplementary greenhouses, insectaries, utility buildings, and specialized equipment also will be required.

The following more detailed presentation of the forestry program is organized under the goals and problem areas set forth in the agricultural research program, as modified to feature forestry.

GOAL I - TO INSURE A STABLE AND PRODUCTIVE FOREST ECONOMY
FOR THE FUTURE THROUGH WISE MANAGEMENT OF
NATURAL RESOURCES 1/

The Nation's forest resources, including soil, water, timber, wildlife, and range, provide the basis for economic growth and an adequate supply of forest products. Essential natural resources must be maintained, developed, and used to meet production and general welfare needs. This involves reducing soil erosion and controlling water runoff. It includes increasing our efforts to further improve multiple use forest management. The rate of improvement must be stepped up to maintain a satisfactory resource base for the projected increase in population. The size of the effort to be achieved in problem areas in Goal I is as follows:

Number and Title of Problem Area <u>2/</u>	Scientist Man Years (SMY's) <u>3/</u>		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
101 Appraisal of Soil Resources	11	13	17
102 Soil Structure and Soil, Plant Water, Nutrient Relationships	21	24	32
104 Alternative Uses of Land	2	11	11
105 Conservation and Efficient Use of Water for Agriculture	36	58	69
107 Technology of Watershed Con- servation and Management	74	113	178
108 Economic and Legal Problems in Management of Water and Watersheds	4	9	15
109 Weather Effects, Probabilities and Agricultural Decision Making	6	10	16
110 Appraisal of Forest and Range Resources	57	73	113
111 Timber Management	272	272	319
112 Range Management	57	61	77
Total	540	644	847

1/ This and subsequent statements of goals are adapted for forestry from the statements of goals in A National Program of Research for Agriculture.

2/ Problem Area Numbers and Titles correspond with those assigned in A National Program of Research for Agriculture.

3/ Data in this and subsequent tables include SMY's for USDA, State Agricultural Experiment Stations and land-grant universities, and participating forestry schools at non-land-grant State institutions.

101 - Appraisal of Soil Resources

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	11	13
USDA	2	4

For a number of years, agricultural agencies have been appraising and mapping the Nation's soil resources. Initial emphasis has been on agricultural lands. However, soils information for forest and range lands has become more essential as management needs have increased in intensity. Recently, as a consequence of this need, there has been some specific effort devoted to appraising forest soil resources. This has been tied in with the national survey of agricultural lands, a total coordinated program.

General soils information has broad utility. Sanitarians and home builders use the information to judge the ability of soils to absorb septic tank effluent, architects and developers use it for site evaluation and foundation designs, program planners and other public officials use soil surveys for both general and operational planning of land use in rapidly expanding areas. Information on forest soils including depth to water table, depth to rock, bearing strength, flood hazard, and soil erosion potential, is useful for estimating tree species suitability in planting programs, for planning logging road locations, in selection of watershed treatments on a sound basis for yield improvement, and for obtaining estimates of the risk of soil slippage.

Questions to be answered require investigation in the following areas:

- a. Determining the characteristics, potentially useful in description and inventory, which develop in forest soils of varying parent material due to type of forest cover. This type of fundamental information is needed in all regions but the research should have greater emphasis in areas of rough, mountainous terrain where knowledge of agricultural soils is less readily applied to uncultivated lands.
- b. Developing knowledge of forest soils, correlated with taxonomic classification, to provide a basis for interpreting soil survey information in land management planning and action programs involving logging, grazing, waterflow, or other uses of forest land.

- c. Locating the areas of soil and climate which have special significance in the administration of forests and ranges, such as where soil erosion potentials are high, where land slippage and avalanche hazards may be a problem, or where maintenance of vegetative cover is particularly difficult. Information on this problem is needed in areas of broken topography throughout the Nation but especially in the West.
- d. Appraising the effect on forest soils of different levels of management and manipulation required for such activities as logging, grazing, change in water yield, and other land uses. This is of greatest importance where timber management is intensive or where grazing is a significant part of land use.

102 - Soil Structure and Soil, Plant, Water, Nutrient Relationships

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	21	23
USDA	3	9

Knowledge of soil relationships is fundamental to intensive forest and range resource management in all regions. Chemical and physical characteristics of the soil and nutrient interactions in the plant-soil-water environment largely determine responses in the forest ecosystem. They help determine the ability of plants to withstand attacks of diseases and insects.

Energy balance, nutrient cycles, soil morphogenesis, and response of soil to forest management are involved. Information on the details of these intricate processes and their effect on site productivity provide the basic data for allocations in multiple-use management that make full use of the soil resource without depleting it.

Research questions on soil structure and nutrient interrelationships require research in the following areas:

- a. Factors which limit root development of trees and associated vegetation, together with practical methods for ameliorating the unfavorable conditions.

- b. Ways in which forest practices can be used to aid forest soil development through basic studies of processes; the chemical, physical, and biological elements involved and the effect that different environments may have on them.
- c. The effect of physical, chemical, and biological properties of soils on soil structure, resistance to erosion, availability of plant nutrients, and the general environment for roots of trees and associated vegetation.
- d. Chemical changes of nutrient elements in different kinds of soils and the factors affecting uptake by plants.
- e. Alternative combinations of fertilizer, water, and plants for efficient use of the combined resources from range and timberlands.

104 - Alternative Uses of Land

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	9	9
USDA	2	2

Alternative uses of forest and range land need to be evaluated to determine which uses will provide the greatest short and long range social and economic benefits and how such uses may effect the long run productivity potentials of the land. Population growth, advances in forest technology, changing consumer demands, urban and suburban growth, rising recreational needs and other factors result in changing demands upon the supply of forest land. Soil and forest conservation in water, watershed, and recreation programs and policies must be based upon the relative advantages of alternative land uses.

Research questions in the alternative uses of land require research in the following areas:

- a. Inventory and appraisal of land uses to supplement the data obtained in appraisal of forest resources.

- b. Improved techniques and methodology for appraisals such as aerial and orbiting satellite photogrammetry, utilizing concepts and skills at centers of similar research for other end uses.
- c. Models and parameters for evaluating economic benefits.
- d. Appraisal of future forest land requirements for nonforestry uses, such as agricultural, highway, urban, and industrial development, with emphasis generally on the eastern situation but including areas of rapid development in the West.
- e. Long term impacts on resource productivity of uses like grazing or timber production.
- f. Economics of conservation and management programs and practices as needed for appraisal of alternatives.
- g. Impacts of alternative government programs on forest land use.
- h. Impact of tax policies on forest and range land use.
- i. Impact of technology on forest and range land use.
- j. Legal impediments to efficient forest land use.
- k. Impact of forest land ownership patterns and trends.
- l. Impact of population growth on forest land use.

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	34	42
USDA	24	27

Virtually all of the Nation's water supply arrives as precipitation upon the land. Seventy percent of this supply is used in evaporation and transpiration (about two billion acre feet). The remaining 30 percent is subject to increasing competition among agricultural, industrial, and domestic users. Forest and related range lands make up a large proportion of the headwater collection areas for the Nation's rivers and streams. Thus, forestry plays a key role in determining efficiency in collecting, storing, and conveying existing water supplies.

Research questions related to conservation and efficient use of water for agriculture require research in the following areas:

- a. Fundamental equations involved in moisture and heat flow in soils for better procedures to monitor and improve effectiveness of water storage in the soil profile and underground aquifers. The need is nation-wide.
- b. Analyses and determination of water use characteristics of individual plant or tree species, especially phreatophytes reaching the water table, that determine the total amount and rate of evapotranspiration losses and the ways in which populations of these species increase and spread through studies of their physiology, ecology, and water use processes. Emphasis is needed on this problem in the Southwest.
- c. Methods to make beneficial changes in energy dissipation and utilization in the soil-plant-atmosphere relationship.
- d. Management practices, plant varieties, and environmental requirements to make more efficient use of water through the various stages of tree growth.
- e. Alternative techniques for reducing water loss from plants, soil, snow, and water surfaces, with emphasis on problems in the West and at high elevations.
- f. Soil surface and profile management or modification practices to enhance water infiltration, transmission, and storage.

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	22	42
USDA	91	136

All of the major rivers of the United States have headwaters in forests, associated range lands, or alpine regions. More than half the water flow of the country originates in such areas. Whether this water flow is beneficial or harmful, is well regulated sustained flow of good quality or erratic and silt laden, is contingent to a major degree upon how the headwater lands are managed. Generally accepted estimates of water use indicate a doubling in consumption by 1980. A logical place to look for additional supplies or improved timing of such supplies with the quality needed is in the headwaters. At the same time, there are constantly increasing pressures to use these same lands for a variety of products and services in addition to their watershed function. Conflicts in use may result, requiring adjustment in management practice.

Research questions on watershed management require investigation in the following areas:

- a. Ways to improve and predict the quantity, quality and timing of water yield from forest watersheds including the relationships and processes of water movement, and manipulation of vegetation growing under different soil and climatic conditions.
- b. Techniques to improve timing of water yield especially to delay seasonal flow from alpine snowfields in the mountains of the West, through investigations of relationships between wind, snow drifting patterns, snow metamorphosis and control of accumulation and melting processes.
- c. Methods for quantifying the role of soil and vegetation in the hydrologic performance of watersheds and river basins and the impact of management practices which change characteristics of vegetation.
- d. Protection requirements for maintenance of stable forest watershed conditions under logging, grazing, or other uses, with specific attention to varying soils, slopes, vegetation characteristics, and rainfall amount and intensity.

- e. Control of erosion and mass movement of various soils, by investigation of soil characteristics, soil water relationships and processes under different patterns of climate, and of the techniques for efficiently and effectively stabilizing eroding slopes.
- f. Procedures for identifying sediment sources and causes, predicting and measuring sediment deposition, and developing methods for sediment control.
- g. Development of guides for the location, design, construction, and maintenance of logging roads on forest lands, based on characteristics of soils and surface and subsurface movement of water so as to prevent accelerated erosion and sedimentation.
- h. Ways to restore and stabilize forest lands disturbed by strip mining and associated activities in Appalachia, and ways to reduce the acidity, sedimentation and flooding in affected streams through studies of the chemistry of spoil banks, the movement of water through the spoil, selection of species and establishment of both woody and herbaceous vegetation and the engineering aspects of soil placement.
- i. Flood reduction through forest practices as they may affect accumulation and melt of snow, disposition and use of soil moisture, and surface and subsurface movement of storm water.
- j. Determination of the climatic and snow conditions in the mountains of the West and in Alaska which cause avalanche conditions as a basis for forecasting avalanche hazards.
- k. Development of methods to improve production of forest crops through water control in wetland forest areas in the southeast and Lake States, including knowledge of basic hydrology and soil relations.

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	3	4
USDA	6	11

The need for increased supplies of useable water continues to rise sharply with expanding populations, industrial development, and income levels. Many areas have already reached the limits of economic development of available water supplies. At the same time, increasing competition from other uses of watershed lands and increasing pollution of water supplies tends to reduce water yields and quality. There is thus a growing need for information on prospective demands for water in different areas, the costs and benefits of alternative land uses and land treatments, and needed adjustments in legal or other institutional factors that affect production and use of water.

Research on economic and legal problems of water should emphasize the following:

- a. Determination of the costs of producing increased supplies of water of useable quality through various land treatment measures on forested watersheds, benefits from prospective use of increased water supplies for agricultural, industrial or other purposes, and the economic impacts of watershed treatment measures on multiple uses of the land for timber, range, or other purposes.
- b. Clarifying the economic and legal aspects of practices that result in pollution of water supplies.
- c. Improvement of legal and institutional arrangements, including cost-sharing of watershed management programs, to achieve desirable levels of watershed development and use.
- d. Development of models for calculating net benefits from watersheds under varied planning objectives, land uses, and land treatment measures.

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	6	8
USDA	4	8

The need for continuation and expansion of research in weather modification and control is emphasized in recent reports of both the National Science Foundation Special Commission on Weather Modification and the National Academy of Sciences panel on Weather and Climate Modification. The future holds many possibilities for weather and climate changes ranging around plants and animals. The potential impact on forests and ranges affects the growth of vegetation, its protection, and its influence on watershed effectiveness. Research in forestry has three tasks: (1) React and adjust to existing climate, (2) Specify modifications that benefit the forest, and (3) Learn how modifications proposed by others will affect natural ecology.

Research questions to be answered on weather and forestry should emphasize the following:

- a. Understanding the response of organisms to sequences and duration of weather events.
- b. Probabilities of occurrence of extreme weather conditions critical to forestry operations, such as severe lightning storms in the Rocky Mountains, hurricanes in the Southeast, glaze storms in the mid-south and mid-west, Santa Anna winds in the Pacific Southwest and severe windstorms in other regions.
- c. Knowledge of the biological consequences of weather modifications.
- d. Understanding the phenomena of hail and other severe storms and the relationships between such storms and the production and quality of forest and range crops.
- e. Remote sensing technology needed to detect ecological change resulting from weather modification, using expertise at locations where related research is under way.

- f. Knowledge of microclimate and its influence on plants; e. g., frost protection, shades, shelters, and mulches.
- g. Closely allied research is included in 203 - Prevention and Control of Forest Fires.

110 - Appraisal of Forest and Range Resources

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	26	43
USDA	47	70

Appraisals of forest and range resources of the Nation are essential periodically to determine the adequacy of public conservation policies and programs and to guide the development of private forest and range enterprises.

The timber resources of the Nation including over 500 million acres of commercial forest lands vary greatly in productivity and availability for industrial use. They show widely divergent trends in growth, depletion, and quality. The increasing use of resource data to evaluate future needs for Federal and State forestry programs and to guide the continuing expansion of wood using industries in various regions makes it imperative that appraisals of timber resources be intensified and kept up to date.

Range resources of the Nation comprise over 900 million acres of forage producing land including about 245 million acres of forest-related ranges. These lands vary widely in productivity, condition, and potential importance for sustaining livestock and wildlife. There is growing need for a comprehensive appraisal of range conditions and opportunities for improving capacity and use to meet future demands for livestock forage, and for wildlife habitat.

Inventory data on forest water resources and recreation potentials also are basic to satisfactory management of these resources, and to accurate appraisals of the need for specific lines of research.

Research questions to be answered require investigation in the following areas:

- a. Determination of types of information needed and standards of estimate to maximize utility of information at least cost and assure comparability of data included in national and regional summaries.
- b. Improvement of techniques to reduce costs and increase the usefulness of information obtained, including emphasis on aerial photography, remote sensing, computer programming, and trend projections.
- c. Appraisals in each State to provide up-to-date information on the quantity, quality, and productivity of forest and range resources, individually and integrated for multiple use, to be used in evaluating the Nation's forest resource situation.
- d. Appraisals to guide public and private investment in resource programs for problem areas such as Appalachia and Northern Great Lakes.

111 - Timber Management

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	78	99
USDA	194	220

Timber culture and management are directed at producing adequate supplies of timber of suitable quality at reasonable cost, by methods that harmonize with other forest uses. Included is fundamental research on ecology of forest trees and plant communities, management of forest vegetation for other uses than timber, and methodology in administration of forest properties. Prospective timber demands for 2000 A.D. are nearly double those of today in volume, and high-quality valuable hardwood species required by the Nation's furniture and veneer industries are already in short supply. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive timber culture on the most accessible and productive sites, and methods for combining timber culture with other uses on the remaining sites. The

major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each timber type has distinctive silvicultural characteristics. Research devises improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives. The timber resource on National Forests alone is valued at over \$12 billion. The estimated annual cost of timber management and measurement on all ownerships is nearly \$500 million.

Research questions in timber culture and management require investigation in the following areas:

- a. Physiology and ecology of forest trees and plant communities.
- b. Seed orchard management, harvesting, processing and storage methods for seed of major commercial species with emphasis on high value hardwoods in the East, pines in the South, and Douglas-fir in the West.
- c. Nursery culture, planting, and direct seeding.
- d. Cheaper ways to convert western brushfields to timber stands.
- e. Techniques to encourage natural regeneration to perpetuate desirable forest species.
- f. Use of prescribed fire and other measures to control competing vegetation and stand composition.
- g. Special techniques for long-term management of forest vegetation in wilderness and park areas.
- h. Theory and instrumentation for measuring and predicting timber growth, yield, and quality.
- i. New mathematical approaches to decision-making processes in administration of forest properties.
- j. Ways to reduce damage to forest crops by birds, rodents, and browsing animals, with emphasis on northern hardwood seedlings and seeds of all major species.

112 - Range Management

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	10	13
USDA	51	64

Native range in the United States includes over 900 million acres, approximately 245 million acres of which are associated with forest and woodland. Forest related range is a continuum of sites and productivity potential from the deserts of the Southwest and the sea-level grasslands of Florida to the Alpine herblands of the high Rockies. Intermingled timber and rangelands are common in all regions, requiring consideration of many joint problems. About half of the feed for beef cattle and three-fourths of the feed for sheep is supplied for at least six months of the year by range forage. In addition, rangelands are important for watershed protection, soil stabilization, wildlife habitat, and recreation.

Research questions in range management require investigation in the following areas:

- a. Range characteristics including the identity, physiological requirements, and nutritive value of range forage plants.
- b. Understanding range ecosystems and their biotic and physical components.
- c. Ecological relations of rodents, insects, and diseases to forage plants and range conditions.
- d. Genetic improvement of western browse plants for forage as well as for protection and aesthetic purposes.
- e. Control of undesirable range plants through fire, chemical, mechanical and biological measures.
- f. Practices for conversion of brush and low-value trees in the West to grassland.
- g. Revegetation of deteriorated areas by seeding desirable species, including genetic improvement of range forage plants.

- h. Systems for grazing western ranges and forests so as to increase forage yields and protect watershed values.
- i. Management practices that will harmonize grazing with timber growing, wildlife, recreation, and other land uses.
- j. Projecting future demand for range forage and other benefits normally related to the wise use of rangelands.

GOAL II - TO PROTECT FORESTS FROM FIRE, INSECTS, DISEASES,
AND OTHER HAZARDS

Lower unit costs and reduced risks result from eradication or control of diseases and pests, fire, pollution, and other stresses. Serious disruptions in the flow of forest products and services can be avoided when these production hazards are reduced or eliminated. The size of effort to be achieved in problem areas in Goal II is as follows:

Number and Title of Problem Area	Scientist Man Years (SMY's)		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
201 Control of Forest Insects	147	237	317
202 Control of Diseases of Forest Trees	94	159	212
203 Prevention and Control of Forest Fires	60	101	151
214 Protection of Plants and Animals from Harmful Effects of Air Pollution	1	6	11
Total	302	503	691

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	72	102
USDA	165	215

During one year insects kill enough commercial sawtimber to build over a half-million homes. They exact a great toll of smaller size trees, killing at least a billion cubic feet and reducing the growth of surviving trees by three-quarters of a billion cubic feet. Epidemic losses, substantially greater and unpredictable, spread wherever trees are found, over forests, farms and urban areas. Increasingly involved are values other than timber, beauty and tree cover of parks and recreation areas are destroyed, wildlife habitat is changed, roadside trees are eliminated and fire danger is increased. In all regions forest growth is susceptible to damage, particularly during periods of drought or other forms of environmental stress. Forest insect research can reduce substantially the continuing losses to forest, shade, and roadside trees, to forest products, and to woody plants on game ranges and recreation sites. Chemical pesticides offer most promise for early solution of some pressing insect problems and specific formulations have been developed for control in a number of instances. Less hazardous biological controls are highly desired but take more time to develop and may not be adaptable to some problems. Research on both chemical and biological methods is thus required.

The research questions to be answered require investigation in the following areas:

- a. The biosystematics, biology, ecology, physiology, and genetics of forest insects and their parasites and predators, with emphasis on bark beetles and insects attacking hardwoods.
- b. Factors that predispose trees in scenic, recreation, range and wildlife habitat areas to insect attack.
- c. The nature of genetic resistance of trees and woody shrubs to insect attack.
- d. Population dynamics of forest insects for early detection of trends and the role of biological environmental factors affecting outbreaks.

- e. Early detection of potential outbreaks by remote sensing, biological sensors and other techniques, making full use of ongoing research that is related.
- f. Reduction of insect damage through integrated control systems that include combinations of silvicultural, biological, or improved chemical techniques.
- g. Parasites, predators, and diseases for control of damaging insects.
- h. Safer and more specific chemical and biotic insecticides including systemics.
- i. Identifying and synthesizing insect attractants and repellents.
- j. Direct control through radiation, chemical sterilization, hormone disturbance and sound.
- k. Equipment and methods for applying controls.

202 - Control of Diseases of Forest Trees

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	54	72
USDA	105	140

Forest disease research is essential to protect and enhance the social and economic value of trees in forests and parks, on farm woodlots, and along streets and highways. Diseases reduce the utility of trees for beauty and recreation, for game management, and for timber production. They kill trees, discolor foliage, retard growth, cause decay leading to breakage and windfall, and destroy wood in use. Annual disease losses to timber production are estimated at 20 billion board feet--enough lumber to build two million five-bedroom frame houses. Chestnut, a tree highly valued as an ornamental and for its wood, fruits, and extractives, was eliminated from American forests by one introduced disease. Today's urban sprawl, wider highways, larger airports, new reservoirs, abundant outdoor recreation, air pollution, prolonged droughts, and warming climatic trends create expanding zones of ecologic tension that accentuate tree disease problems.

The research questions to be answered require investigation in the following areas:

- a. Taxonomy, cultural characteristics, nutritional requirements, enzyme systems, physiology and ecology of infectious pathogens (fungi, bacteria, viruses, nematodes, and mistletoes) and associated organisms in trees, in the soil in which they grow, and in wood in service.
- b. Epidemiology of major destructive diseases (root and heart rots, cankers, stem rusts, dwarf mistletoes, and systemic wilts) and methods of quantifying their impact on the multiple uses of trees and forests.
- c. Nature and action of noninfectious causes of tree diseases (air pollutants, climatic and weather variations, and nutritional imbalances). Closely related research is included in problem area 214 - Protection of plants and animals from harmful effects of air pollution.
- d. The nature of genetic tree resistance to pathogens with emphasis on the rusts of southern pines and white pines, and annosus root rot in both the East and West.
- e. Cultural practices which deter the spread and intensification of pathogens such as annosus root rot and pine rusts.
- f. Effectiveness of parasitic, predatory and antagonistic organisms for biological control of pathogens.
- g. Physiological and biochemical basis for safe and effective chemical disease control measures.
- h. Equipment and methods for applying disease controls.
- i. Improvement of techniques for handling wood during processing, and development of new processes, treatments, and structural designs to lengthen its service life.

203 - Prevention and Control of Forest Fires

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	6	9
USDA	95	142

Forest fire research develops the knowledge and technology for adequately safeguarding natural resources on more than one billion acres of public and private forest and range lands and the co-mingled and adjacent urban developments. Forest fires damage outdoor recreation, destroy natural beauty, injure natural resource-based industries, destroy timber, sweep rural communities and even cities, take human lives, and create air and water pollution. Research efforts must focus on the development of new fire prevention methods to reduce the number of fires, new technology for fuel hazard reduction, and improved systems for rapid fire reconnaissance and powerful attack on threatening fires. Major research efforts must be centered on the prevention of conflagrations. In 1964, the prevention of one conflagration spawned from a roadside fire in a western forest would have saved \$23 million in costs and damages, and loss of life and homes. Conflagration potential also has serious implications in national defense, justifying study of preventive measures.

Spinoff from forest fire research has included major contributions to atmospheric science through (1) studies of lightning and its suppression through cloud seeding, and (2) investigations of micro-weather and particularly air movement in relation to forest cover. Also, fire research has contributed to development of equipment and techniques for remote sensing now being used in research on distant identification of soils and vegetation.

The research questions to be answered require investigation in the following areas:

- a. Weather modification including atmospheric system dynamics, patterns, and characteristics.
- b. The physics and chemistry of combustion.
- c. The behavior of fires as influenced by fire-starting agents, atmospheric circulation and local weather, fuels and topography.

- d. Fire intelligence systems, including electronic methods, remote sensing, automatic measurement of fire environment, and computer integration of these factors into a fire danger rating system.
- e. Fire prevention methods to deal with human actions causing forest fires, including incendiarism.
- f. Prevention of lightning fires in the West. Related research is included in problem area 109 - Weather effects, probabilities, and agricultural decision making.
- g. Reduction of fuel hazards through physical, chemical, and prescribed fire treatments.
- h. Aerial and ground fire attack methods.
- i. Integrated fire control and forest management systems which minimize fire losses and foster development of natural resource values.

214 - Protection of Plants and Animals from Harmful Effects of Air Pollution

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	3	5
USDA	3	6

Evidence of the effects of air pollution on trees has received public notice for many years. Tree mortality and growth impairment have been spectacularly evident around smelters and other industrial plants at many locations in this country and throughout the world. These localized problems have excited interest and some remedial action. More recently the less spectacular but more widely distributed effects of air pollution have been noted in all the places where trees grow, in forests, in farm woodlots, in parks and other outdoor recreation areas, and in lawns and along streets and highways.

Some trees are quite susceptible to damage. The evergreens are particularly vulnerable because they retain their foliage throughout the year and the same needles remain on many species for several years, lengthening the period of exposure.

Three classes of pollutants are of particular interest to forestry. These are sulfur dioxide, fluorine compounds and photochemical smog. Damage from sulfur dioxide to eastern white pine and quaking aspen has been noted in the East and to alders, birch, and true firs in the West. Tests of the effects of fluorides on a range of plants showed that western larch, ponderosa pine, and lodgepole pine were among the more susceptible species. Ponderosa pine has been severely damaged by fluorides in the vicinity of aluminum smelting. Photochemical smog damage has been noted on ponderosa pine in the southern California mountains and on eastern white pine.

There is strong variation in individual tree response to air pollution. This not only indicates promise for development of resistant strains for planting in polluted environments but also provides a ready means for monitoring low, but still phytotoxic levels of certain gases not easily detectable with instruments. Grafts from single resistant or susceptible individual eastern white pines exhibit the same response as the trees they were taken from and have proven useful in research.

Research questions to be answered should emphasize investigation of the following areas:

- a. Sources of concentration of damaging air pollutants and the intensity and frequency of damage.
- b. Tolerance of forest vegetation to air pollutants, singly and in combination, especially to low level pollution for prolonged periods of time.
- c. Alternative methods for protecting trees from air pollutants.
- d. New varieties of plants that are resistant to air pollution.
- e. The role of trees in removing pollutants from the environment.

GOAL III - TO PRODUCE AN ADEQUATE SUPPLY OF FOREST
PRODUCTS AT DECREASING REAL PRODUCTION
COSTS

Domestic needs for forest products will be up an estimated 80 percent by the year 2000. This increased volume should reach the consumer at the lowest possible cost. The size of the effort to be achieved in problem areas in Goal III is as follows:

Number and Title of Problem Area	Scientist Man Years (SMY's)		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
301 Improvement of Biological Efficiency of Trees	110	152	184
302 New and Improved Forest Engineering Systems	13	32	51
303 Economics of Timber Production	20	38	54
316 Farm Adjustment and Management	--	9	12
Total	143	231	301

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	97	114
USDA	55	70

Today's forest practice is based almost entirely on wild forest trees. Unlike crop plants, trees have not undergone centuries of selection and breeding to make them more useful to man. There is strong evidence that through application of genetic principles we can produce tree varieties that grow twice as fast as the parent stock, that resistance to most major destructive pests can be bred into trees, that specified wood properties can be produced at will, and that yields of sap or gum can be increased several times. It should be feasible to develop straighter form, fewer limbs and resistance to climatic extremes.

Timber-related crops such as naval stores, maple sap and Christmas trees can be improved through research. Research on genetic improvement of slash pine for oleoresin production has gone through two tree generations in 30 years and has produced trees yielding twice the normal quantity of oleoresin. A hybrid pine, resistant to the pine reproduction weevil, has been developed for planting in California on sites where native species are susceptible. The long period required for production of tree seed and the start of a new generation now limits the potential in forest genetics. Strong support, leading to a breakthrough on this problem, is essential to satisfactory progress in the future.

The research questions to be answered require investigation in the following areas:

- a. Reproductive processes basic to induction of early flowering.
- b. Basic genetics fundamental to improvement of forest species through breeding.
- c. The extent of individual and geographic variation within important tree species.
- d. Selection and breeding of trees that are superior for the production of high quality timber and timber-related products.

- e. Selection and breeding of trees for urban environments. Trees with resistance to air pollution, temperature and moisture extremes; with dense, broad crowns for shade, and with improved aesthetic qualities are needed. Related research is included in problem area 905 - Trees to enhance rural and urban environment.
- f. Effects of radiation on forest vegetation and use of radiation as an improvement technique through induced mutation.
- g. Techniques for the production of timber-related crops from improved strains.

302 - New and Improved Forest Engineering Systems

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	12	19
USDA	20	32

Forest engineering systems need to be improved to reduce forest management and timber harvesting costs, to stabilize and increase rural payrolls, to reduce accidents, to obtain fuller use of all the wood in the forest, and to provide higher returns to landowners and wood processors. In several states, because of a large volume of small-size timber and high percent of defect, the economic feasibility of harvesting timber is limited. A ten percent reduction in harvesting costs would mean a cost avoidance of \$160 million annually. Watershed and recreation developments are in need of specialized engineering systems to permit full development of recreation opportunities and protect public health.

Over 100 billion board feet of timber in Alaska and the Western states are inaccessible due to the high cost of road construction, steep terrain, soil conditions, and lack of equipment suitable for timber harvesting.

The research questions to be answered require investigation in the following areas:

- a. Harvesting systems for mountainous or other difficult access terrain.
- b. Low-cost bulk transport of wood chips through such means as pipelines or belt conveyers.
- c. Harvesting systems for low-quality timber in areas such as Appalachia, northern New England, and the Lake States to make use of available resources and clear the way for better growing stock.
- d. Mechanization of production of specialized timber related crops such as naval stores and maple syrup.
- e. Mechanized systems for regeneration of timber and forage.
- f. Engineered systems for watershed structure installations and cover manipulation.
- g. Special equipment for wildland recreation to protect health, safety and aesthetics, to facilitate recreational use and integration of recreation with other uses.
- h. Special equipment for forestry practices and harvesting of timber from farm woodlots.

303 - Economics of Timber Production

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	12	21
USDA	26	33

Timber production efficiency research determines how income can be increased through the most effective use of labor and capital. Such information is generally lacking for the wide variety of forestry investments possible in different areas. Returns of expenditures for planting,

stand improvement, and other timber growing activities vary widely throughout the nation depending on many cost factors, the quantity and quality of timber yields, and local market conditions. Past study of these elements of production has yielded information on how they react individually to the range and variety of conditions encountered. There is opportunity now through systems analysis to develop combinations that promote maximum efficiency for the entire timber growing enterprise. Identifying the most profitable opportunities for expansion of public forestry programs and for private investments on forest lands is basic to efficient allocation of the funds available for timber growing.

The research questions to be answered on economics of timber production require investigation in the following areas:

- a. Evaluation of opportunities for profitable timber growing in relation to different combinations of forest types, site, kinds of ownership, size of holdings and market factors.
- b. Potential returns from investments in different areas in forest protection, road construction, planting, thinning, and other forestry measures.
- c. Capital requirements for development of public and private forestry operations.
- d. Systems analysis to determine the most efficient combinations of practices for public and private timber production, with emphasis on selection of alternatives for management of the National Forests.

316 - Individual Farm Adjustments and Management

	<u>1972</u>	<u>1977</u>
Recommended SMY: <u>1</u> / States	9	12
USDA	0	0

1/ There was no forestry input in this problem area in 1965. This omission should be corrected. Farm woodland acreage is large, widely distributed, and has sufficient potential for development to require attention in a well balanced research program for forestry.

Farm business management research with emphasis on forestry is needed to help farm operators use their woodland and range resources more effectively. Farm woodlands make up 30 percent of the commercial forest land. They make up a significant part of farm acreage. In fact, woodland acreage as tabulated in the 1959 Census of Agriculture exceeded cropland in the Northeast, South Atlantic, and East Gulf regions. Together with about an equal acreage of land in other classes of small ownerships, farm woodlands furnish about half of the present timber cut. The condition of timber growing stock found by the Forest Survey and experience in public forestry programs point to unrealized opportunities for strengthening farm enterprises.

Forest-related range lands associated with ranch enterprises in the West are a related problem of importance.

Questions on forestry in farm management require research on the following items:

- a. The resources and schedule of activities required for efficient management of farms which incorporate varying proportions and types of farm woodland.
- b. The effect of farm location, size, and resource situation on how and when woodland products should be sold.
- c. The means of using farm labor, equipment, and other resources available on the farm to produce and harvest woodland products.
- d. The attitudes of farm owners and related institutional factors on the place of woodlands in the farm enterprise.

GOAL IV - TO MAKE MORE DIVERSE AND CHEAPER FOREST
PRODUCTS AVAILABLE THROUGH DEVELOPING NEW
AND IMPROVED PRODUCTS AND PROCESSES AND
ENHANCING PRODUCT QUALITY

During early settlement in the United States, timber was the primary material for construction, for farm and domestic implements, and the host of other items that could only be fashioned from an easily worked, attractive, and versatile material. As industrialization has proceeded, accompanied by the rise of and competing materials, wood has retained favor with consumers for many uses. Assurance for the future that needs for wood will be met must include more use of low quality timber, more efficient processing, and better design of fabricated units. The size of effort to be achieved in the problem area in Goal IV is as follows:

Number and Title of Problem Area	Scientist Man Years (SMY's)		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
401 New and Improved Forest Products	244	353	464

401 - New and Improved Forest Products

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	93	164
USDA	260	300

The objective of forest products research is to develop the technical knowledge that will allow these products to continue to satisfy steadily increasing consumer needs and wants, and to provide for most effective use of the Nation's timber resources. About five percent of the present gross national product originates in timber-based economic activities. Shipments from timber-based primary manufacturing plants are valued at over \$10 billion annually. One out of every 20 people employed in the United States works in these industries. The economic health of these industries is dependent on continuing increases in the efficiency and technical proficiency of **their operations**.

Increasing pressure on the better quality timber is at the heart of the supply problem. The raw material base for forest products needs to be broadened to include a greater range of species and qualities, and the use of material that now is discarded as waste. Twelve percent of logging residue and 20 percent of plant residue, a total of 32 percent, makes no contribution to supply. The demand for timber products is expected to increase 80 percent in the next 35 years. This increase in consumption will require adjustment in type of products and their manufacture to make the best use of the raw material supply.

Knowledge of the quality, characteristics and utility of wood of a wide range of tree species must be increased. Modification of present products and development of new products to provide greater serviceability and performance are required. Products that have less exacting raw material requirements will aid in adjusting to changes in available timber. And improvements in processing are needed to maintain the competitive efficiency of production.

A particular opportunity exists in areas of the country where a main natural resource is an over-abundance of low-quality wood. Research leading to better use of this resource can lead to establishment of new industry and general economic growth and development of these distressed areas. Also, it can provide the economic incentive needed for more effective management and improvement of their timber stands.

The research questions to be answered require investigation in the following areas:

- a. Basic knowledge about the anatomical, mechanical, physical and chemical properties of wood and its components, and performance in use.
- b. Effect of environmental factors such as heat, light, and moisture on wood and wood products in use.
- c. Relation of timber species and quality to wood properties and use.
- d. Development of sound technical bases for effective engineering use of many wood species including more efficient design of wood members from southern pine and Douglas-fir and other species that are or can be used for structural purposes.
- e. Better ways to use wood in panels, laminates, and assemblies.
- f. Improved performance of wood, as through overlays, combinations with other materials and better product designs.
- g. Pulp yield and quality improvements for production of better fiber products with emphasis on species with good intrinsic properties but that currently are little used and blocking improved timber management.
- h. New and improved processes for production of chemicals and chemically-based products.
- i. Improved products, reduced costs, and reduction of waste through development of more effective manufacturing processes such as sawing, drying, machining, pulping and assembling.

- j. Effective treatments to protect wood in use from fire, fungi, insects, sunlight, high temperatures and widely changing environmental conditions. Related research is included in problem area 201 - Control of forest insects, 202 - Control of diseases of forest trees, and 706 - Control of insect pests of man and his belongings.
- k. Expanded uses for bark and wood extractives, including wood resins and naval stores products in regions of large scale primary processing such as the South and West.
- l. Methods for removing moisture from wood and for stabilizing its dimensions.
- m. Improved methods for storage, transportation, and handling of chips for pulping.
- n. Emphasis on pollution avoidance or control in the development of products and processes. Related research is included in problem area 901 - Alleviate soil, water, and air pollution.

GOAL V - TO IMPROVE EFFICIENCY IN THE MARKETING SYSTEM

A large share of the consumer dollar is spent for marketing rather than producing forest products. Greater efficiency of assembling, handling, processing, packaging, storing, transporting, wholesaling, retailing, and installing forest products would reduce prices paid by consumers, increase returns to producers, and expand markets. The size of effort to be achieved in problem areas in Goal V is as follows:

Number and Title of Problem Area	Scientist Man Years (SMY'S)		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
501 Improvement of Grades and Standards for Forest Products	16	23	26
502 Development of Markets and More Efficient Marketing of Timber Products	32	38	54
506 Supply, Demand and Price Analysis for Forest Products	12	18	21
507 Competitive Interrelationship in Agriculture	--	1	3
Total	60	80	104

501 - Improvement of Grades and Standards

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	2	3
USDA	21	23

Grades and standards describe the characteristics of a product so that producers and processors, and buyers and sellers can gage product utility. Tree grades provide a means of more effectively valuing growing stock, thus assisting the producer to set specific goals for silvicultural practice and to obtain true value for stumpage. Log grades reduce the uncertainty in product transactions and permit segregation of logs for their highest use, to the benefit of both buyer and seller. Standards for processed forest products likewise assist buyers in obtaining product characteristics they desire and sellers in obtaining appropriate compensation for what they sell. Because wood is by nature a very heterogenous material, the efficiency of the whole structure of wood markets depends to a large degree on the existence of accurate and understandable grades and standards.

The research questions to be answered require investigation in the following areas:

- a. Analysis of the bases for selection of quality criteria used in process and product specifications.
- b. Determination of the relationships between product specification, physical characteristics of trees and logs, and process capability.
- c. Development of techniques for evaluating product quality level.
- d. Description of product quality characteristics and variations for which grades and standards should be developed.
- e. Evaluation of the effectiveness of particular grades and standards in meeting the requirements of buyers and sellers.

502 - Development of Markets and More Efficient Marketing of Timber Products

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	13	19
USDA	25	35

Development of markets and more efficient marketing of timber products helps to achieve the potential incomes and employment that could be supported by the Nation's timber resources. Nonwood products have penetrated many traditional markets for wood materials in construction, manufacturing, shipping, and other uses, even though available timber with good intrinsic characteristics is underutilized in many areas. Research to evaluate opportunities for market expansion through more efficient processing and marketing of timber products to better meet consumer requirements and preferences is essential to maintain and improve the competitive position of wood and wood products.

The research questions to be answered in forest products marketing require investigation in the following areas:

- a. Analysis of performance requirements for various wood products in construction and other mass markets.
- b. Determination of consumer attitudes and preferences for various wood materials and relationships to performance requirements.
- c. Changes in processing and distribution practices and in consumer use of products that would lead to increased marketing efficiency, maintenance of product quality, and lower costs of timber products.
- d. Appraisals of the economic feasibility of developing markets for underused or low-quality timber in regions such as the Rocky Mountains and in areas such as the Appalachians where rural development is urgently needed.
- e. Cost reductions through improved organization and management of marketing and processing firms.

- f. Relationships involved in the size of marketing firms, number and composition of products handled, and marketing and processing costs.
- g. Effects of equipment design, plant layout and design, and alternative handling methods on handling and processing costs, product losses and end-product quality. Studies of primary processing would be largely in the heavy production areas in the South and far West. Problems in secondary processing may require investigation in any region.
- h. Effects of such characteristics of raw material supply as quality, dependability, and availability within an economic distance on marketing and processing costs and user demand.
- i. Systems analysis to guide selection of alternatives in arriving at the most efficient combinations of practices for turning wood into finished products.

506 - Supply Demand and Price Analysis

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	11	11
USDA	7	10

Improved forecasts of supply, demand, and prices of forest products are essential to more efficient and orderly planning for production and marketing. Individual producers, processing and marketing firms, and end users base decisions upon information about the forecasts of future supply, demand and price conditions. Sound public policy of forest conservation is dependent upon such information. The forest supply industries need similar data on goods and services purchased by producers so that they may make orderly adjustments to prospective changes in supply demand and price of production inputs.

Research questions on supply demand and price require investigation in the following areas:

- a. Development of improved techniques for collection of data.
- b. Effects of changes in supply of individual commodities upon stumpage prices, marketing spread, and consumer prices.
- c. Effects of changes in supply of one commodity upon prices and spreads for a substitute product.
- d. Effects of income, level of education, type of residence and other consumer characteristics on demand.
- e. Effects of such characteristics of supply as variability of production upon user demands.
- f. Seasonal patterns of consumer demands.
- g. Effects of new production and processing technology and technological developments in production of synthetics on demand for forest products.
- h. Impact of current and proposed government programs on supply demand and price.
- i. Evaluation of methods of collecting data and of disseminating market information.
- j. Related research is included in problem area 507 - Competitive interrelationships in agriculture.

507 - Competitive Interrelationships in Agriculture

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	1	2
USDA	0	1

Competitive relationships in forestry change with the development of new technology, shifts in consumer tastes and organizational changes in the supply, production and marketing sectors of the industry. An understanding of the changing competitive position of regions and industry groups is necessary for sound management decisions, particularly long-term investment decisions by forest land owners and timber processors. Public policy decisions are improved through better knowledge of their differential effects upon the competitive position in different regions.

Questions on competitive relationships in forestry require investigation in the following areas:

- a. The competitive position of different regions and industry groups in the production and marketing of forest products.
- b. The potential impact of changes in transportation costs, technological change, and differential rates of population growth and other factors on the competitive position of the various regions producing or handling the more important products.
- c. The potential for one forest product or service to compete successfully with other forest products and services for the use of the land, labor, and other production resources in a geographic area.
- d. Accessibility, productive capability of land, and interregional comparative advantage as factors influencing long-term timber supply and short-term public timber growing policy. Related research is included in problem area 506 - Supply demand and price analysis.

GOAL VI - TO ASSIST DEVELOPING NATIONS

The sense of moral responsibility of the U. S. impels us to help people in need. At the same time our abundant fiber and wood product technology can be an effective instrument of foreign policy. Forestry technical assistance will help developing nations produce more for their own needs, contribute to their economic growth, and open up sources of supply for us. Net imports of forest products now make up 13 percent of the Nation's total supply, including about half of the hardwood veneer and plywood. Much ingenuity will be required in order to accomplish these objectives within the framework of present world markets and internal economies of the countries involved. The size of effort to be achieved in Goal VI is as follows:

Number and Title of Problem Area	Scientist Man Years (SMY's)		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
603 Technical Assistance to Foreign Countries	4	19	25

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	10	14
USDA	9	11

In recognition of our vital stake in a peaceful and prosperous world, the U. S. has undertaken substantial programs of technical assistance to developing countries. Economic development in most of them, at least in the early stages, is largely a matter of improving the productivity of their land or finding exploitable natural resources. Besides agriculture, timber is often one of the few resources they have; forests of South America, for example, account for 47 percent of the land area. Timber development supplies a means of capital accumulation and provides an expanding market for the products of other industries, thus promoting the countries' economic development. Also, some of our requirement for imports can be supplied from developing countries.

Forestry participation in programs of technical assistance to developing countries has not involved large numbers of scientists as compared to those in food programs, but it has been important in a number of areas. Specific targets are not significant because the level of program will be dependent on foreign policy decisions yet to be made. But, forestry will continue to offer opportunities for adding to the economic strength of developing nations, and to our potential supply of needed raw material. The projections included for forestry are in recognition of this fact.

Research to assist developing countries includes:

- a. Develop and adapt land and timber inventory techniques to provide reliable estimates of available forest resources.
- b. Determination of the timber species in developing countries that are most likely to have a competitive advantage in world markets, and the market development required to realize this potential. Most of the more economically advanced countries, with the exception of Canada and the Soviet Union, must import forest products.
- c. Development of harvesting technology adapted to the specific equipment and skills available.
- d. Evaluation of extension programs aimed at application of forestry practices.

GOAL VII - TO PROTECT THE WELL-BEING OF THE AMERICAN
PEOPLE

As part of the broad range of activities related to protecting American consumer health and well-being, there is need to control insect pests of man and his belongings. Part of this need for protection occurs during recreational use of the forest environment. Part is related to protection of forest products. The size of effort to be achieved in Goal VII is as follows:

Number and Title of Problem Area	Scientist Man Years (SMY's)		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
706 Control of Insect Pests of Man and His Belongings	6	8	10

706 - Control of Insect Pests of Man and His Belongings

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	4	5
USDA	4	5

Ticks, mosquitoes, flies, and other insects are a great annoyance to man. Insects also cause serious damage to homes and other belongings of man. Included are such pests as termites, carpenter ants, and powder post beetles. Insect damage to wood in use is estimated at nearly \$210 million annually, excluding control costs. Needed is information on the biology of a number of insects affecting man, as the first step in developing safe, effective, and economical means for their control.

Questions about insect pests of man require investigation in the following areas:

- a. Studies on the biology and ecology of ticks, termites, and powder post beetles. Related research is included in problem area 201 - Control of forest insects.
- b. Development of attractants and repellents.
- c. Development of biological methods of control.
- d. Development of safer and more effective chemical methods of control.

GOAL VIII - TO RAISE THE LEVEL OF LIVING OF RURAL PEOPLE

The practice of forestry has a strong impact on the welfare of rural people. Research can increase the contributions that forestry will make to a more abundant life, and this research is included in this program. However, because of its specific direction and emphasis research to achieve this goal is classified under the other goals for agriculture.

GOAL IX - TO PROMOTE COMMUNITY IMPROVEMENT INCLUDING DEVELOPMENT OF BEAUTY, RECREATION, ECONOMIC OPPORTUNITY AND PUBLIC SERVICE

Trees and forests enrich community life and provide a variety of services to the general public. Non-commodity use of forests is increasing and assuming major significance in the life of the Nation. Facts are needed to support community programs aimed at improving coordinated use of economic and natural resources. The forest provides the characteristic environment of one-third of the country. The size of effort to be achieved in problem areas in Goal IX is as follows:

Number and Title of Problem Area	Scientist Man Years (SMY's)		
	Inventory of SMY's Reported for 1965	Projected SMY Effort for	
		1972	1977
901 Alleviate Soil, Water and Air Pollution	7	26	45
902 Forestland Recreation	20	101	128
903 Multiple Use Potential of Forestland and Evaluation of Forestry Programs	14	32	63
904 Wildlife and Fish Biology and Habitat	52	65	97
905 Trees to Enhance Rural and Urban Environment	35	56	76
907 Improved Income Opportunities in Rural Communities	6	13	19
Total	134	293	428

901 - Alleviate Soil, Water, and Air Pollution

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	16	28
USDA	10	17

Soil, water and air are being polluted with a variety of substances, both inorganic and organic. It is not always possible to assess the severity and extent of this pollution. Nevertheless, it is clear that ever increasing amounts of pollution have been occurring in recent years. Some of the more readily apparent contaminants are organic pesticides, growth regulating chemicals, crop wastes, salts used on roads for deicing, lead from fuel combustion and radioactive fallout. The impact of research of the problem has been dissipated by lack of a sustained, integrated effort to examine and evaluate the severity of the many forms of contamination. Pollutants resulting from forestry operations include pesticide residues, smoke from prescribed fires, burning of waste, and effluent from processing plants. And study of these problems is an integral part of the development of the management or processing system involved.

Research questions in alleviating soil, water, and air pollution require investigation in the following areas:

- a. The character, intensity and causes of the pollution from forest practices and forest-based industries and the frequency of their occurrence.
- b. Metabolism and natural degradation of a wide variety of pollutants.
- c. Public policy that would influence the occurrence of pollution and its alleviation.
- d. Alternative methods of reducing and controlling pollution to levels that are not harmful to man, plants or animals, or methods that will prevent emission of the pollutant.
- e. Reducing pollutants originating from timber-based industries with emphasis on pulp mill operations.
- f. Base line population densities of plants and animals in polluted and unpolluted habitats.
- g. Minimum environmental quality standards for plant health.

- h. Alleviating odors, dust, and noise.
- i. Developing useful products from wastes to help offset the costs of disposal, and properly emphasizing pollution control as a part of all research on new wood product development.
- j. Control of pollution on recreation areas.
- k. Related research is included in problem areas 214 - Protection of plants and animals from harmful effects of air pollution, 202 - Control of diseases of forest trees, and 401 - New and improved forest products.

902 - Forestland Recreation

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	51	68
USDA	50	60

Forestland recreational research provides information to guide the management of rural lands for recreation, and to help coordinate this use with other land resource uses. The research involves problems in management of the resource and the socio-economic relationships of users to the resource. Recreation demands not only continue to increase, they are becoming more varied and more complex, and at a time when pressure on all forest resources is accelerating. In the last 35 years, recreational use of National Forests alone has increased from five million to 150 million visits. USDA spent \$30 million in 1965 to provide outdoor recreation on National Forests. A tripling of outdoor recreation demand by 2000 A.D. is forecast. This gives an indication of the urgency of the problem and the challenge to research.

Questions research must answer to guide sound development and management of both public and private recreation resources require investigation in the following areas:

- a. Criteria for appraisal of the total resources for recreational use including selection of sites for particular uses.

- b. Developing practical methods to maintain existing recreation sites and restore those depleted by heavy use.
- c. Requirements for aesthetic landscapes and means for producing and maintaining them.
- d. Study of the forest ecosystem in wilderness and wild river areas and the development of methods of protection, management, and use that maintain the value of these resources.
- e. Management systems and facilities which will minimize dangers from fire, avalanches, and other natural hazards to recreationists.
- f. Gaining a better understanding of visitor preferences and attitudes regarding outdoor recreation opportunities.
- g. Procedures for measuring current and prospective demands and estimating future demands in terms of numbers, duration, and type.
- h. The compatibility of various types of recreation use with each other, and development of methods for better integrating these uses.
- i. Methods for improving visitor's understanding, enjoyment, and appreciation of the outdoor environment.
- j. Requirements for successful income-producing outdoor recreation enterprises on privately owned forests and farm woodlands in areas of dense population and restricted public land.
- k. Definition of a classification of area attributes and user needs that will effectively subdivide the heterogeneous activities included in the term "recreation" into categories sufficiently homogeneous to provide a basis for management planning.

903 - Multiple Use Potentials of Forestland and Evaluation of Forestry Programs

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	22	38
USDA	10	25

Most forest areas and related resources can be managed in widely varying combinations depending on the owner's objectives and the allocation of investments for resource development. On more than 300 million acres of National Forests and other public lands, for example, guides are needed to determine the best combination of uses or systems of managing the land for timber, water, forage, recreation, wildlife, or other purposes. Similar criteria are needed to evaluate land use alternatives as a basis for management decisions on private lands.

Forestry programs to increase the future production of timber and related forest resources need to be evaluated to determine their relative costs and effectiveness. Such evaluation of alternatives is basic to the development of sound forestry policies and investment programs. Approximately one-half billion dollars is now spent annually by public forestry agencies and by private industry and organizations for the development and management of forest resources. These programs cover a wide range of conservation activities including protection against fire, insects and disease, reforestation, timber stand improvement, and improved timber harvesting. Various forms of technical and financial assistance provide some 4-1/2 million private owners of forest lands with technical advice and consultation, cost sharing in planting, timber stand improvement and other conservation practices, and assistance in the fields of taxation and credit.

Research questions to be answered require investigation in the following areas:

- a. Development of procedures and criteria for evaluating the relative costs and benefits of alternative land uses and combinations of land uses and land treatment measures.
- b. Through systems analysis, determining the relative efficiency of various combinations of measures in obtaining increased output of timber and other forest-based products and services.

- c. Providing basic data on output potentials and operational guidelines for land managers to use in developing multiple use management plans and program decisions, with emphasis on the problem of public lands.
- d. Evaluations of the response of forest owners and operators to various types of public and private forestry assistance programs.
- e. The size and combination of forestry programs that would most effectively meet projected demands for timber and other forest products and services in future years.

904 - Wildlife and Fish Biology and Habitat^{1/}

In Forestry Environments--

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	37	56
USDA	28	41

Forest wildlife and fish research aims to assist in meeting the ever-growing demands of hunters and fishermen, as well as to provide food for certain segments of the population. Hunters and fishermen spend \$3 billion annually for equipment and services. Approximately a billion acres of forest and related rangeland in the United States provide food and cover for 10-15 million head of big game and countless numbers of small game and non-game birds and animals. Within this vast rural area there are an estimated one-half million miles of fishing streams and over 10 million acres of lakes. Depletion of vegetation and accelerated erosion impair fish production through reducing food and cover, increasing water temperatures, and causing sedimentation of spawning beds. To maintain a continuity of wildlife and fish it is essential to know how to maintain their habitat and to determine the biological requirements and relationships of each species, including food for their normal growth, and cover.

^{1/} The forestry research is presented here. Agricultural research in the problem area is described on pages 59, 60, and 61.

Research questions in forest wildlife and fish management require investigation in the following areas:

- a. The life histories and population dynamics of forest wildlife and fish including non-game and vanishing species.
- b. The ecological and physiological requirements of forest wildlife and fish.
- c. The effects of pesticides on forest wildlife and fish.
- d. Selection and genetic improvement of both native and exotic food and cover plants for use in improving habitat and increasing carrying capacity.
- e. Improving forest wildlife habitat through such measures as seeding, planting, prescribed burning, spraying, and fertilizing.
- f. Improving fish habitat and food supplies through management of streamside vegetation, channel stabilization, and creation of spawning beds.
- g. Estimates of carrying capacity for various forest sites under varying conditions of management impact.

In Agricultural and Marine Environments--

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	60	90
USDA	--	--

There are, in addition to our forests and associated ranges, millions of acres of agricultural land that support large populations of wildlife. Crop and pasture lands provide necessary food and cover for many species of animals and birds. Lakes and rivers in agricultural areas and farm ponds provide readily accessible opportunities for recreation and are potentially important sources of food. In addition, the public is becoming increasingly aware of aesthetic values in the out-of-doors and, consequently, concern themselves to a far greater extent with the fortunes of non-game species such as song birds. Such animals occur abundantly on agricultural lands, and practices which result in harm to these species frequently result in vigorous objections from the public.

The expansion of our urban population has reduced the amount of available farm lands while our food needs are increasing. Compensating intensive management of crop and pasture lands has necessitated the development of new methods for maintaining and increasing beneficial fish and wildlife populations, while checking the numbers of depredatory species. The achievement of these goals frequently requires research investigations of organisms from the top to the very bottom of the web of life. Ostensibly non-economic life forms may be found to be the keys that unlock new concepts in wildlife and fisheries management. Changes in cropping or forage harvesting practices may endanger food supplies of birds and animals, while the planting of shelterbelts may encourage their survival. Environmental contaminants may reduce the productivity of pond or marine fish and shellfish, while fertilization and cultural practices may augment catches.

There has been a growing recognition, that the stability of environment is related to the number of species of organisms within them. Land use practices, whether for the processing of wastes, control of pests, harvesting of wild crops or increasingly intensive crop production in agriculture, forestry and wildlife management, tend to lead toward the establishment of monocultures and increasingly simplified environments with a scarcity of certain organisms and over abundance of others. This phenomenon has serious consequences and may even include changes in the composition of the atmosphere. One of the basic questions towards which agricultural research may be directed is this: can ecological diversity be maintained together with high levels of food and fiber production? If we are able to discover how to manipulate the environment to produce stability of populations while maintaining high agricultural production, an important contribution will be made to human welfare.

Productive management of wildlife and fish on agricultural lands and water impoundments will depend on research in the following categories:

- a. Interrelationship and behavior patterns of wildlife species.
- b. Improved management alternatives of combined farming-game and/or fish management operations.
- c. Influence of environment on populations.
- d. Food chain structures.

- e. Biological, physiological, and nutritional factors influencing growth and survival.
- f. Improvement of habitats - population dynamics of fish and wild-life species as affected by changes in agricultural practices, such as crop rotation versus fixed habitats, and farm practices including irrigation that affect the quality of run-off waters.
- g. Intensive culture of economically important fresh water and marine organisms to improve yield, and of game animals and birds for game and farming enterprises.
- h. Demand characteristics of man's desire to hunt and fish.
- i. Prevention and control of wildlife and fish diseases and parasites with special emphasis on zoonoses (diseases transmittable from wildlife to man, or from wildlife to domestic animals and fowl, or from wildlife to domestic species to man).
- j. Wildlife and fish genetics and physiology to upgrade health, efficiency in food conversion, and breeding stocks for game or fur-farming programs or pond culture, and develop strains or hybrids which can thrive in environments not now occupied by native stock.
- k. Importation of exotic wildlife and fish species suitable for game, fur or fish farming in environments for which native stock are not suitable (a breeding duck for southern farm ponds, for example).
- l. Improvement of harvesting regulations to maximize legal harvesting opportunities on a sustained yield basis. (Both farm and non-farm game and fish.)
- m. Reduction of damage to farm crops, municipal buildings, park structures, and reduction of hazards caused by pest species. (Blackbird and crow damage to crops, starlings in cities, large flocks of birds around airports.)

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	29	39
USDA	27	37

Research on tree culture provides some of the scientific knowledge required to maintain or improve the quality of the rural and urban environment, and to enhance natural beauty through special-purpose tree planting. Trees have an important part to play in improving the quality of American life. Rapid urbanization is multiplying the need for special tree plantings to screen junkyards and highways, suppress noise, slow the movement of dust and debris, and to provide shade and beauty. In rural America, especially in the Great Plains, research provides information on tree improvement and culture for shelterbelts to protect crops, animals, and farmsteads. In the cities, research is needed to find species and techniques so that trees can survive smoke and air pollution, compacted soils, deficient or excess moisture, and other urban conditions. Under new highway and urban programs, millions of dollars are being devoted to the use of trees to improve the rural and urban environment.

Research questions on the use of trees to improve the environment and to aid natural beauty programs require investigation in the following areas:

- a. Selection of species and strains best adapted for special-purpose tree planting.
- b. Soil and site requirements for species that are needed to improve the environment.
- c. Methods of site preparation and planting appropriate for special-purpose tree planting.
- d. Culture and maintenance of urban trees and stands.
- e. Culture and improvement of shelterbelts.
- f. Related research is included in problem areas 102-Timber management, 201 - Control of forest insects, 202 - Control of diseases of forest trees, and 301 - Improvement of biological efficiency of trees.

	<u>1972</u>	<u>1977</u>
Recommended SMY: States	8	13
USDA	5	6

Forests are the major natural resource available to many rural communities. This is particularly true in areas of economic stress. Thus the decisions on best use of resources to solve community problems often involve the forest, its products and services. Involved is determination of the potential for providing adequate income opportunities so that communities can retain more of their young people and finance the kind of public and private facilities and services that make attractive places in which to live. It includes also, exploration of alternatives which call for adjustment to a stronger economic framework through shifts in population. The problems of depressed rural areas are of vital concern to many large urban centers which are inadequately equipped to assimilate a flood of ill-prepared rural migrants.

Research to improve the income of rural communities include studies to determine:

- a. The processes of economic growth and decline in forest-related communities and related factors including the characteristics of the population, the natural resource base for the area, and location advantages and disadvantages.
- b. Potentials for further development of forest resources, including the associated supply, processing, and marketing facilities.
- c. The prospects for attracting desirable industries as a means of increasing local employment opportunities and providing a more adequate tax base for the support of community services.
- d. The kinds of public programs needed to stimulate economic development and the effectiveness of existing programs in accomplishing this objective.
- e. Factors associated with the occurrence of forest associated depressed areas, and policy measures that might prevent such areas from falling behind the rest of the economy, or facilitate adjustment to a more favorable economic pattern.

PUBLIC RESEARCH RESPONSIBILITIES

Agriculture has had an integrated, jointly financed Federal-State program of research since establishment of the land-grant system over 100 years ago. The pattern applies to this forestry research program. It permits sustained attention to the major national problems, their regional ramifications, and the more local but nevertheless important and demanding problems closely interrelated with the local environmental situation. Many forestry problems are broadly regional in scope. The ranges of some of the major timber species extend through several States. As a consequence, a well coordinated research effort is essential to give proper emphasis to the broad problems and to add strength from a united approach.

Forestry research, like that for agriculture, is largely a public responsibility. Protection of the forest soil, its infiltration capacity, and the vegetation that holds it in place is essential to a strong renewable resource situation. It is essential for sustaining at a high level, the services desired by the public from forest land. Development of knowledge to guide wise management and use of the forest and range resources must include the principles with broad significance as well as consideration of the details of application in local environments. Thus a diverse and widespread program of research is required. The thousands of individual forest landowners, timber producers, and others are not able to furnish, nor can they justify furnishing the research effort required to supply this knowledge.

Forestry research must assure a continuing flow of new information to back up the effective and efficient management of Federal lands which comprise 324 million acres or 42 percent of the total forest land in the Nation. Over half of this acreage is in the National Forests administered by USDA. A few of the States have substantial forest acreages which must depend largely on public research for the information backing up their management.

More than half of the Nation's commercial forest land is in small private ownerships averaging less than 60 acres in size. The owners of these small holdings also are dependent almost exclusively on publicly funded research for information basic to the protection and use of this major national resource.

Public forestry research also must back up Federal and State programs such as those administered through the State and Private Forestry organization in the U. S. Forest Service and The States' Extension Services. Some of the agricultural conservation programs also have an impact on the management of farm-related woodlands.

The State University research organizations in addition must train most of the scientists who will be responsible for administration of forest properties and those who will engage in research. As in other fields, most teaching and research functions can enhance each other. Centers of excellence are essential for high level training of scientists capable of dealing with the complex problems that more and more typify the intensive forestry of the modern day.

RESOURCES REQUIRED FOR THE PROGRAM

Research Personnel

Well-trained scientists are the key to productive research. The effort recommended in this long-range program will produce the necessary quantity and quality of urgently needed research results only if there is an adequate supply of well-trained, imaginative, and dedicated research people. Today's forestry scientists are far better trained than those of ten years ago. Yet, a higher proportion of tomorrow's scientists must acquire research preparation equivalent to the Ph.D. and post-doctorate levels. These highly trained men are needed because the more complex research problems will yield to solution only in the face of increasingly sophisticated theoretical approaches and techniques.

What number of scientists will be needed to execute the expanded research effort? If research training must be expanded, how may this be done? Although a detailed statistical basis for analysis of these questions is unfortunately not available, the broad outline of the answers can be satisfactorily judged from existing information.

This report reflects the number of research leaders rather than the total number of research personnel. It is, therefore, a measure of the future need for individuals trained to the Ph.D. level and the possible availability of such research-leadership personnel. Already there is a considerable nucleus of research leaders, with about two-thirds of them in forest industry, two-thirds research, and one-third in Federal and Forestry School-State programs.

The total scientific manpower requirements needed to carry out research for forestry can be calculated from the Federal-State and from the expected research program manpower needs for forest industries. At present, forest industries account for 67 percent of the forestry research leaders and these industries will continue to draw heavily on the available pool of well-trained scientists. Since private industry research is a vital and essential segment of the total effort, The Forestry Research Task Force expects this research area to grow commensurately with the Federal-State program. Assuming the same rates of growth for all agencies, future needs for research leaders are projected as follows:

<u>Research Group</u>	<u>Scientist-Man-Years</u>		
	<u>1967</u>	<u>1972</u>	<u>1977</u>
Federal	972	1388	1805
School-State	472	788	1122
Forest Industries	<u>2916</u>	<u>4374</u>	<u>5832</u>
Total	4360	6550	8759

To these totals must be added a factor for staffing of forestry schools to accomplish the necessary training-staffing beyond that needed to meet the research responsibilities of the schools in the expanded program. Such staff increases are expected to total at least 200 by 1972 with a somewhat smaller added increase by 1977.

Also, there must be added a factor for losses due to retirement, death, and other causes. The Long Range Study of Agricultural Research uses a factor of 28 percent for these losses, with the losses distributed uniformly over the 10-year period.

When these factors are applied to the respective categories of the previous table, the number of new leaders that would need to be trained to effectively man the research program of the three research groups would be as follows:

<u>Research Group</u>	<u>New Research Leaders that Must be Trained</u>		
	<u>By 1972</u>	<u>Additional by 1977</u>	<u>Total 1967-1977</u>
Federal	552	553	1105
School-State	582	581	1163
Forest Industries	<u>1866</u>	<u>1866</u>	<u>3732</u>
Total	3000	3000	6000

A National Program of Research for Agriculture analyzed the research manpower needed to man the expanded program of agricultural and forestry research by 1972 and 1977 and foresaw shortages of qualified research leaders in individual areas. Forestry is one of these shortage areas.

Although significant parts of the research manpower needs of forestry possibly can be met by recruitment of research leaders from the total Ph.D. pool, both the magnitude and the nature of the needs in forestry dictate that the long range goal should be to encourage and to stimulate an increase in research leader production.

The present forestry research leaders, estimated at 4360 in 1967, have the Ph.D. or equivalent training in the 20 or more specializations in forestry and forest products, in basic biological fields, in economics and sociology, in physics and mathematics, in the multiple disciplines of engineering, and in other fields. About three-fourths of those in Federal and School-State research, a total of about 1083, are the products of Forestry Schools. The Forest Industry research scientists are predominantly the products of engineering schools, with an estimated 25 percent or 729 the products of Forestry Schools.

If we assume a similar ratio of research talents and leadership in 1972 and 1977, there should be an added 1319 scientists trained to the Ph.D. in Forestry Schools by 1972 and a similar number (1317) additional from 1972-1977, making a total of 2636 for the next ten years.

Less than 100 Ph.D. degrees were awarded by Forestry Schools during each of the past five years. There has been a sizable Ph.D. enrollment increase but this has not yet resulted in proportionate increase in degrees awarded. The existing Ph.D. enrollment increase, much of it stimulated by improved assistantship programs financed through Federal and State funds, should result in the production of at least 110 Ph.D.'s annually in the next few years.

The need for the training of over 2600 research leaders by Forestry Schools over the next 10 years calls for almost a three-fold increase in the Ph.D. training programs of these schools. With sizable increases in school staffs, and the availability of more adequate Federal, industry and state funds for research assistantships, the expansion necessary to accomplish the training goals should be possible.

Facilities and Equipment

The success of research efforts is determined also by the adequacy of facilities and equipment. The 1965 inventory of facilities for agricultural research showed a total of 12 million square feet of office and laboratories, of which 1-1/2 million feet were judged inadequate and in need of replacement.

Forestry research shares with agricultural research the need for additional office, laboratory, and supplementary facilities to support the present program adequately as well as to provide for the future. Using overall averages from the 1965 inventory, forestry research is estimated to have occupied 1.7 million square feet of the total of 12 million square feet of office-laboratory available at that time.

The estimated need for 1972 under the presently recommended program is 2.5 million square feet and in 1977, 3.6 million square feet of gross laboratory and office space.

State and Federal programs will need approximately 1.9 million square feet added to present office-laboratory space by 1977. Each will need half of that amount completed by 1972. About 0.2 million square feet are now obsolete or overcrowded. Older facilities will need to be replaced and overcrowding relieved by new construction.

Most of the Federal research is on university campuses. At some locations there is justification for separate State and Federal facilities. At others, requirements can be combined. At still others there may be opportunities to include forestry and agricultural needs in one structure. Each situation presents an individual problem requiring an individual solution. Therefore, a listing of requirements at specific locations is beyond the scope of this report.

Both Federal and State funds support the present research efforts. An increase in both will be required for the recommended program. Part of the needed increase is to cover the advance in costs of doing research, which is variously estimated at 4 to 8 percent per year. The remainder of the increase will provide additional scientists and their support for a more adequate program.

The funds appropriated under the Hatch Act and the McIntire-Stennis Act are allocated to the States on a formula basis. Additional flexibility in funding is provided through joint State-Federal funding of selected research projects and through project grants of Federal funds to State and other Universities. The means are available, therefore, to sustain broad programs through formula funding. In part, also, they are available for building centers of excellence, through selective funding, but here some additional legislative authority may be needed.

Supplementary facilities such as greenhouses, insectaries and utility buildings including structures at experimental forests and ranges also are necessary.

ADEQUACY OF PROGRAM LEVELS RECOMMENDED FOR 1972 AND 1977

The Forest Research Task Force believes the program projected by A National Program of Research for Agriculture is sufficient to meet most forestry research needs. However, in certain rapidly expanding and new research areas in forestry the assigned Scientist-Man-Years are too small to provide the vigorous research program that is demanded. In fact the requirements for new knowledge in forest genetics, weather modification, range and wildlife habitat interactions have pushed the present research efforts to, and in some instances, very close to the 1977 projections. Even so, the immediate research needs in these areas are not being met.

Immediate shortages in Scientist-Man-Years are evident also for research concerned with appraisals of forest and related resources. Other areas may need increased support in the next 10 years. However, the major concern now is to point out the immediate problems of adequately staffing these rapidly expanding and new research areas. The needs in these important areas are briefly described in the following paragraphs.

109 - Weather Effects, Probabilities and Agriculture Decision Making

This is a rapidly expanding area of research in forestry. Already experimental success in the reduction of the number of lightning strikes by as much as 30 percent through forestry research indicates the great opportunities for weather modification. A reduction in the number of lightning caused forest fires can result in a savings of millions of dollars in reserve fire fighting manpower and equipment and in the preservation of the timber resource. The assignment of 9 Scientist-Man-Years for 1972 and 15 for 1977 is totally inadequate to fully realize the great opportunities in weather modification. This effort should be doubled by 1972 and tripled by 1977.

Because of the newness of remote sensing, A National Program of Research for Agriculture did not have an opportunity to provide for a comprehensive research program in this area. Provision was made for some research under weather modification; however, increased demands for remote sensing in other areas will necessitate an increased research effort. Remote sensing research directed toward early identification of insect and disease attacks, soil water storage, forest soil productivity evaluation, and resource inventory will require at least 30 Scientist-Man-Years by 1972 and 55 by 1977.

110 - Appraisal of Forest and Range Resources

It seems apparent that the recommended program level for this problem area reflects mainly the survey of timber resources which is now being carried on under the title of Forest Survey. This is the bulk of the present effort and is the area of investigation which automatically comes to mind when survey of forest resources is discussed.

However, the problem area is much broader than just timber. It includes also a survey of range resources which has been recommended a number of times by various advisory committees, and on which there is no action at the present time. It also includes surveys of other resources of the forest such as recreation, water, and wildlife. To increase our knowledge of these resources and bring the survey of timber resources up to an acceptable level with reasonably current data will require a considerably larger effort than envisioned in the recommended program. We estimate the needs as 100 Scientist-Man-Years for 1972 and 130 for 1977, and recommend these levels.

The Forest Survey operates under a statutory limit on Federal funding which has tended to make estimates of future programs quite conservative. The 1965 level of program reflects this restricted view of what is required to provide adequate statistics on timber resources. An increase in the statutory limit is pending. Legislation (HR 8535, S1136) is now before Congress. Additional funding will be required in the very near future in order to permit program development sufficient to meet the need for a more adequate appraisal, as recommended above.

111 - Timber Management

The research in this problem area is quite inadequately described by its title. The title erroneously connotes research of a type generally outmoded in agriculture, which has in recent years been supplanted by much more intensive investigation. These two things, we believe, led to the recommendation that the 1965 level of program be maintained through 1972. Continuation of the 1965 level will put severe restrictions on research which relates to a much broader area than just timber production.

Included in this problem area is a large part of the basic ecological research which is fundamental to much forest management practice for multiple use. For example, the management of wilderness and park areas requires a full understanding of the ecology of vegetative communities in order to safeguard vegetative resources.

The biological basis for selection of alternatives in timber culture and multiple use management is another major area which is largely within the scope of this research. The comprehensive nature of problems needing study and their fundamental importance is emphasized repeatedly in associated economic evaluations where absence of biological data often detract from the impact of the economics study.

Also included in this problem area is research on new mathematical approaches to decision making in the administration of forest properties, regardless of what the output from these properties may be.

Animal damage to forest crops is also included. This is a problem which has received emphasis only recently and one which is critical now in several sections of the country.

We recommend a program level for FY 1972 of 300 Scientist-Man-Years and 330 for FY 1977.

112 - Range Management

Range management research in forestry includes not only the development of forest ranges for beef production but also the protection and improvement of range watersheds, soil stabilization, wildlife habitat, and recreation. The protection and the efficient use of 245 million acres

of forestry-related range land requires knowledge from many disciplines as a basis for multiple use management. The national and international problems of managing these natural grass and browse lands are complex and difficult to solve. An adequate research program for attacking these problems of worldwide significance will require doubling the presently assigned effort.

301 - Improvement of Biological Efficiency of Trees

The task force concluded that the 1965 inventory base was inaccurate due to classification discrepancies. The increase in programs associated with this base was about average for all problem areas. The result after appropriate adjustments have been made in the classification of research on genetics and physiology is to allow for a very limited increase in this research. Advisory groups have recommended much greater emphasis on genetics research. A recent PPBS analysis points to this problem area as one having high potential for payoff. Applying the percent increases to a more realistic base yields estimates for FY 1972 and 1977 of 180 and 200 Scientist-Man-Years respectively. These are much more in line with needs as we see them.

303 - Economics of Timber Production

Here, too, the task force has reached the conclusion that the 1965 inventory base is inaccurate. The percent increase allowed for research in this problem area appears about right, but when this percent is applied to the base, the resulting values are too low to provide the program level sufficient to do the job

There is another factor which adds to the problem of adequately taking care of the needs in economics research. This has to do with the training job the universities have in the economics area. Because of small programs of research in production economics in the past, there is a very limited base for training. Furthermore, with the increase in emphasis on economic studies during recent years, there has been heavy attrition of the available scientific staff, many members of which have been siphoned off to other areas of economics research. Strong support is needed, therefore, to increase the base for training, as well as to take care of immediate needs for research. We recommend 45 Scientist-Man-Years in FY 1972 and 60 Scientist-Man-Years in FY 1977.

502 - Development of Markets and More Efficient Marketing of Timber Products

The projected program level for 1972 in this problem area is very restrictive. There is more adequate but still quite limited provision for 1977. This research is closely related to the problems in economically distressed areas which coincide in many instances with areas where forest lands and forest resources are a large proportion of the economic base. The task force finds little justification for reduced emphasis on research which will have a strong impact in these distressed areas. Our recommendations are 45 Scientist-Man-Years for FY 1972 and 60 Scientist-Man-Years for FY 1977.

904 - Wildlife and Fish Biology and Habitat

The assignment of Scientist-Man-Years to this area of research does not take into consideration the needs for an expanded program for habitat research in farmland. In order to provide some research in this important area of wildlife environment, it was necessary to split the number of available Scientist-Man-Years between research on forest habitat and research on farmland habitat. The number of Scientist-Man-Years for this research area should be doubled to provide for an adequate research program for wildlife habitats in forest, farmland, and marine environments.